Groundwater level fluctuations caused by surface hydrologic pulsing of a wetland

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Introduction

Seasonal or regular energy pulses from the flooding of wetlands not only enhance productivity, but also contribute to the stability of the ecosystem. The initial step in developing a better understanding of the function and importance of flood pulsing in constructed wetlands is an examination of the basic hydrologic conditions that are involved. However, it is difficult to estimate subsurface flow and attempts to construct wetlands that intercept ground water have not been very successful due to limited understanding of locations and hydraulic gradient (Koreny et al., 1999 and Hammer, 1992). This investigation focuses on the dynamics and characteristics of the surface and ground water exchanges caused by the periodic pumping of water into the wetlands.

Site Description

The Olentangy River Wetland Research Park (ORWRP) at The Ohio State University is located on a 30-acre site immediately north of the Columbus campus. Surface water flow through the designed and constructed deep-water marsh wetlands is maintained by continuously pumping water from the adjacent Olentangy River. Water depths in the basins range from 1 to 2 feet, and the surface-water wetland stage varies with the pumping volume (Koreny et al, 1999). The flat to gently rolling land surface at the site is underlain by approximately 100 feet of glacial and fluvial sand and gravel, with thin interbedded deposits of silty sand or silty clay. Silty clay, containing sand, gravel, and cobbles, is prevalent from the surface to a depth of about 10 feet (Koreny et al., 1999).

A total of 29 water table observation wells (wells) and two recording piezometers (R-1 and R-2) have been installed at the ORWRP (Figure 1). Most wells were constructed using 2-inch PVC casing. Three wells had been damaged or destroyed (B-1, C-2, and D-3) and several do not appear to be properly backfilled, sealed, or protected. Well D-1 and the two recording piezometers are protected above ground by an 8-inch steel casing. Inside the casing measured total depths of the wells range from approximately 13 feet to 3 feet below the ground surface (bgs). Total measured depth of R-1 is approximately 17 feet bgs.

Methodology

The field procedures in this investigation involved measuring the depth to ground water in all accessible wells before the initiation of pulsing in the first week of the month, and remeasuring the depth to ground water near the cessation of pulsing approximately 7 days later. An electric water level meter consisting of a plastic tape graduated to hundredths of a foot, attached to a stainless steel probe which emits an audible signal when water is encountered, was used for all measurements. Measurements were made from a permanently marked measuring point on the well casing.

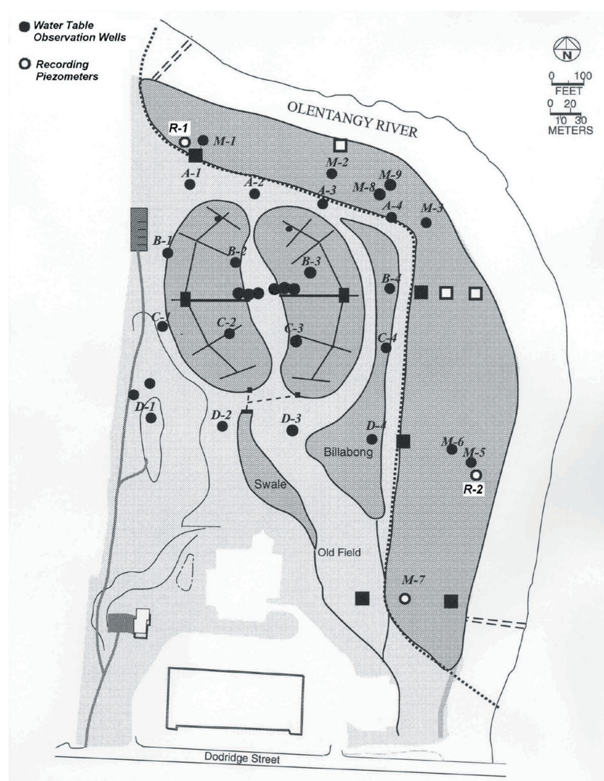

Figure 1. Groundwater table observation wells and recording piezometers at the Olentangy River Wetland Research Park

Ground water measurements were conducted for March, April, May, and June flood pulsing events. In addition, a shaft encoder water level sensor permanently installed in R-1, continuously recorded ground water levels from 15 January to 15 May, 1993.

Data Analysis

Ground water levels measured in the water table observation wells before and near the end of each monthly pulsing were compiled as a series of bar graphs for easy comparison. Results from the May pulsing event showed the greatest change in ground water levels, ranging from 1.0 to 1.5 feet (Figure 2). Changes in ground water levels for the April and June pulsing were typically less than 0.5 feet.

Preliminary before and after pulsing water table elevation maps have been constructed for each monthly episode using measurements from the water table observation wells only. (The greater depth of completion and different construction details precluded inclusion of data from recording piezometer R-1.) Typically, ground water pumped and/or pulsed into the wetlands seeps through the sediments to the water table

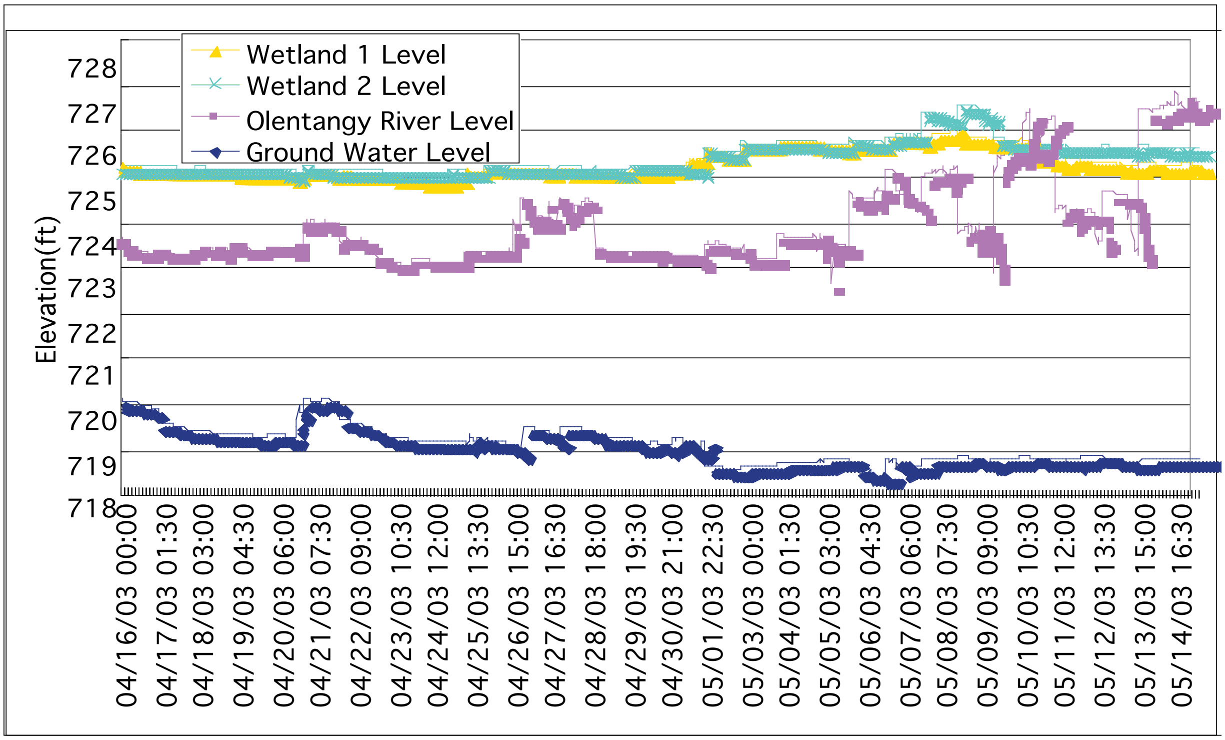

Figure 2. Groundwater level and wetland basin level fluctuations, April 16 to May 14, 2003

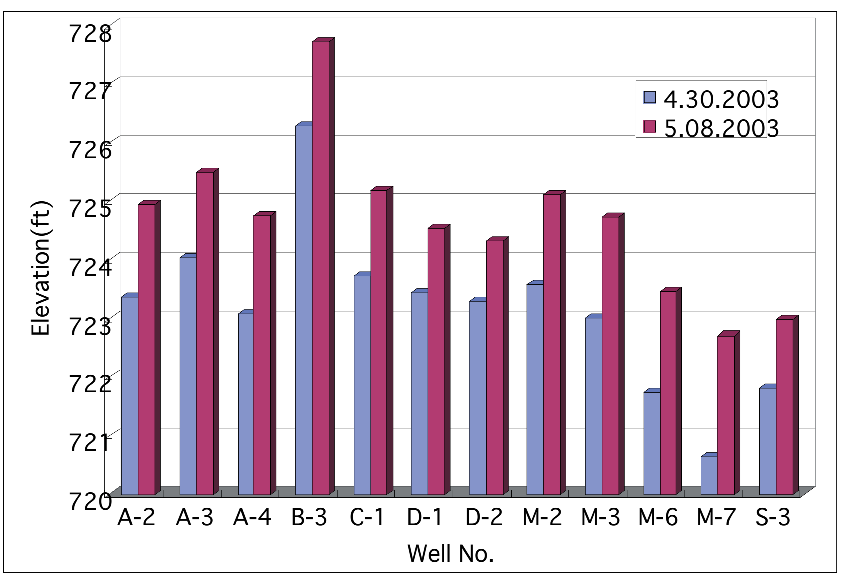

Figure 3. Groundwater table contours before and after May 2003 pulsing

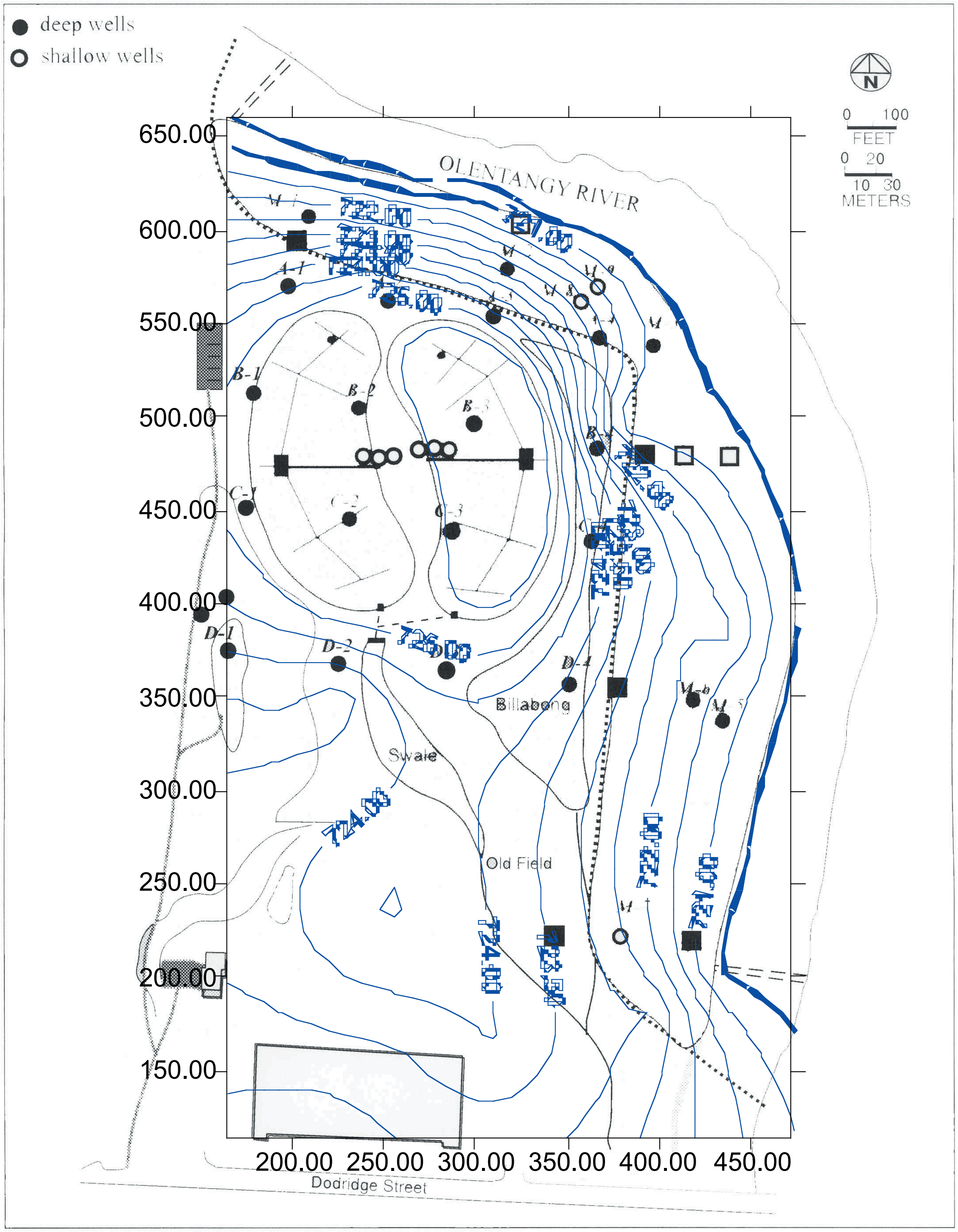

Figure 4. May ground and surface water level fluctuations on April 30, 2003

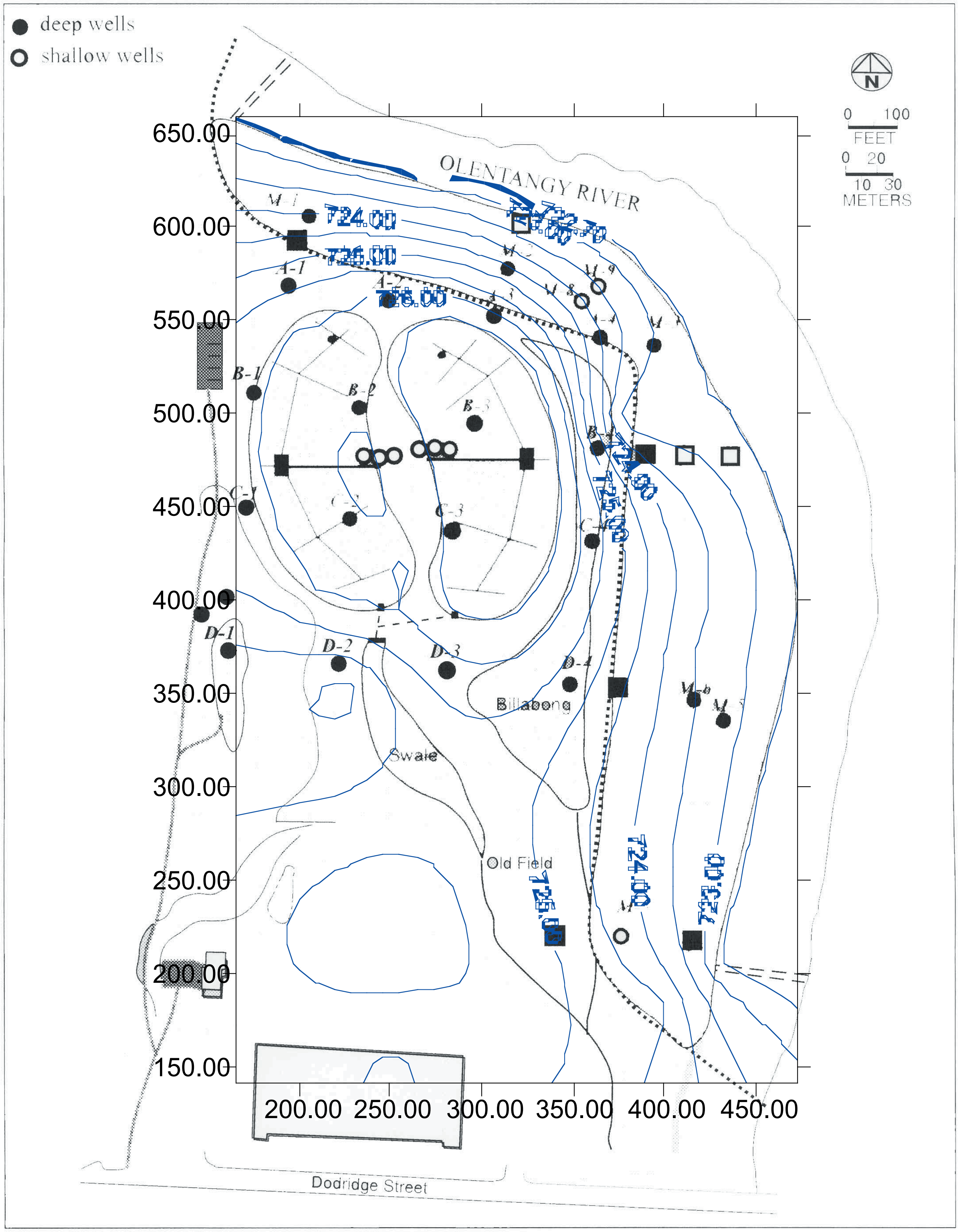

Figure 5. May ground and surface water level fluctuations on May 5, 2003

to be discharged back to the Olentangy River. The higher water level of the wetlands produces a vertical gradient near the river. The increase in the elevation of the ground water table after pulsing is best represented in the results from May where there is a marked increase in the areal extent of the 726 foot contour (Figure 3). Occasionally, water discharged from the ground water to the surface water in topographically low areas (Figure 3). Mid-month to mid-month ground water and surface water level time series plots were produced from the records of R-1. Ground water levels were always lower than surface water levels and exhibited less change than river water levels (Figure 4). Ground water levels, which gradually decreased from spring to summer, more closely matched river levels during the late winter and early spring. This indicates that the Olentangy River was the major source of ground water recharge during this time. Later in the season, snow melt and precipitation appear to have a greater influence on ground water levels.

Conclusions and Recommendations

Investigating surface water and groundwater exchange and interaction is the first step in creating a more complete understanding of the hydrologic cycle of constructed wetlands in a riverine environment. Preliminary analyses of data from this investigation indicate a direct relationship between surface water and ground water levels as a result of flood pulsing at the ORWRP site. The increase in wetlands surface water produced a corresponding rapid, but relatively short duration increase in ground water levels. However, when compared to the magnitude of surface water level changes, ground water levels were more stabile, and were characterized by slow seasonal decreases.

Future investigations should include the installation of addition, properly designed, installed, and protected piezometers and water table observation wells to more adequately define the hydrology, and hydraulic gradient and ground water flow pattern at the ORWRP site. Selected piezometers should be installed at depths greater than 25 feet to define the potentiometric surface(s) of the deeper alluvial aquifers(s) beneath the site and develop a better understanding of regional hydrogeologic conditions

References

Hammer, D. E. 1992. Creating Freshwater Wetlands, Lewis Publishers, Ann Arbor, MI, USA.

Koreny, J. S., W.J. Mitsch, S.E. Bair and X. Wu. 1999. Regional and local hydrology of a created riparian wetland system. Wetlands 19: 182-193.